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THE INFLUENCE OF SEASONAL AND OTHER FACTORS ON THE ACCEPTABILITY AND FOOD VALUE OF THE MEAT OF TWO SUBSPECIES OF CALIFORNIA DEER AND OF ANTELOPE^{1,2}

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INTRODUCTION

FOR MANY YEARS there has been a controversy over the proper season for hunting deer in the central and southern coast ranges of California. The deer in question are the Columbian black-tailed deer, *Odocoileus hemionus columbianus*, which inhabits the north coast from the Oregon line south to San Luis Obispo County, and the California mule deer, *Odocoileus hemionus californicus*, which is found in the area extending from San Luis Obispo County south to Orange County.

Deer in these coastal areas are considered "prime" in August when their antlers are hard and their coats are blue. They enter their breeding season late in September.

One group of public officials and sportsmen believes that the open season should be declared from the time the antlers become hard until the start of the fall rut. The group contends that, from the standpoint of the condition and palatability of the venison and the trophy value of the heads, the deer are prime at this season, and that during the rut, the condition becomes poor and does not improve again until the following year.

Another group of officials and sportsmen points out that since there is great danger of fires being started by hunters at that time of the year in the brush

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lands and grazing areas comprising the watersheds, and that much venison is lost by spoilage in camp and in transport during the warm weather, the open season should be declared in the cool, rainy month of December, after the mating season and before the antlers are shed.

This study was made in order to provide a more sound basis for determining the proper time for hunting deer in these two areas of the state, and to obtain information as to the general condition of the animals and the palatability and food value of the meat at all times of the year.

Since, from time to time, antelope hunting is permitted, and there is some disagreement as to the palatability and food value of the meat of these animals at various seasons of the year, it seemed wise to make a similar study of antelope meat at the same time.

No recent studies of palatability or food value of venison or antelope have been found, except that by Chatfield and Adams (1940) who reported values for the water, protein, fat, and ash content of venison.

In the present study, it has been assumed that conditions which have an effect on the palatability and food value of other meats will be likely to cause similar variations in deer and antelope meat. The factors which have the greatest influence on the palatability of any meat are generally conceded to be: aroma, flavor, juiciness, and tenderness. These factors may in turn be influenced by natural variations occurring in the samples selected, and by the methods used to prepare the meat for analysis.

SELECTION AND PREPARATION OF THE DEER AND ANTELOPE FOR THE EXPERIMENTAL WORK

Five Columbian black-tailed deer and the same number of California mule deer were killed each month for 14 months. The former were all taken from the north side of Mt. Tamalpais in Marin County where an excess of deer had been causing damage to gardens and cultivated areas. The latter were taken from the west central portion of Ventura County in the upper Cuyama and Sespe areas from January through April, 1944, and after that, from Santa Barbara County in the headwaters of the Santa Ynez River in the vicinity of the Gibraltar Reservoir and Big Pine Mountain. The collections were made in Marin County within a few days of the first of each month, starting on February 1, 1944. Collections in the southern counties began the 16th of each month and were usually completed by the 20th, though occasionally it took until the 25th of the month to secure all five animals.

Five California prong-horned antelope bucks were killed in Lassen County each month for 6 months beginning in May and ending in October, 1945.

The hunters attempted to include in the monthly groups of both kinds of animals 1 or 2 young bucks and 3 or 4 older ones, and to kill them instantly by shooting in the head or neck. When the shots accidentally entered the abdomen or hindquarters, and death was not immediate, it was recorded for consideration if the flavor seemed otherwise inexplicably poor. Other factors

recorded by the hunter for each animal were: the dressed weight; general body condition; and the condition of the antlers (for deer only), coat, neck, and testes. The general condition was judged as very poor, poor, fair, good, or excellent, according to the amount of fat shown on the carcass—the greater the amount of fat, the higher the rating given. In order to show the general condition graphically, these ratings were given arbitrary numerical values of 1, 2, 3, 4, and 5, respectively.

In Marin County, where the Columbian black-tailed deer were obtained, a small dairy barn located in the center of the hunting area was used to care for the meat until it was ready for freezing. The carcasses were partially dressed at the site of killing and the dressing was completed at the barn where they were hung until one day after all collections were made. In most cases, this meant a hanging or ripening period of one to three days, after which standard cuts of shoulder, loin, and ham were made from each animal. These cuts, together with the livers, were delivered unfrozen (except for those taken the first 6 months) to the laboratory.

The deer killed in Ventura and Santa Barbara counties, after being partially dressed in the field and sometimes after hanging overnight, were taken to a cold storage plant in the nearest town where they were skinned and hung for two to five days at 36° F. They were then cut into standard cuts, wrapped in locker paper, and placed in a freezing locker (10° F) for several days before delivery to the laboratory. This same procedure was followed with the antelope meat.

At the laboratory, an experienced meat cutter cut the hams and loins of all animals into steaks and chops 1½ inches thick. Two adjoining ham steaks were cut parallel to the aitch bone, one to be cooked for the palatability studies and the other to be used for the fat, moisture, and vitamin studies. Four loin chops, two for the palatability tests and two for analysis, were cut in the region of the second through the fifth lumbar vertebrae. The shoulders were used only for moisture, fat, and vitamin analysis.

The livers were cut into slices 1 inch thick. The frozen ones were softened just enough to permit cutting; the unfrozen ones were cut before freezing.

All of the cuts of meat thus prepared were wrapped in several thicknesses of freezing storage paper and stored in a freezing storage locker at -18° C (0° F) for two to three months until the palatability tests could be made. The unfrozen ones were spread out in the locker to hasten the rate of freezing.

EXPERIMENTAL METHODS

Palatability Tests. The constant temperature method of broiling was carried out under standard conditions, without seasoning, as described in *Meat and Meat Cookery* (1942). The procedure was as follows: After the meat was thawed overnight in the refrigerator, a thermometer was inserted horizontally so that the bulb rested in the center of the fleshiest part of the meat. The meat was then placed on a rack 3 inches from the tip of the flame of a gas oven

broiler which was preheated to and maintained at 175° C (347° F). When the internal temperature of the meat reached 44° C (111° F), it was turned, and when it reached 76° C (169° F) it was removed from the oven and the samples for the shearing and palatability tests were taken at once while the meat was hot.

The livers were thawed just enough to permit insertion of a meat thermometer and were broiled by the same method used for muscle cuts except that the final internal temperature reached was 80° C (176° F). The higher temperature was used because, during the preliminary tests on livers, the judges expressed a preference for them cooked to that degree of doneness. Palatability studies were made only on the venison livers; the antelope livers were unacceptable to all judges.

The Warner-Bratzler apparatus for measuring the shearing strength of meat was used to determine objectively the tenderness of the cooked meats. Samples for the shearing tests were cut parallel to the grain of the muscle with a sharp, cylindrical bore having an internal diameter of 1 inch. They were allowed to cool to room temperature and two cuts were then made on each sample, perpendicular to the grain of the meat, and the shearing force in pounds required to cut through the sample was recorded for each test. Samples from the center of the *longissimus dorsi* muscle of loins and of the *semimembranosus* muscle of hams were used for the tests.

Palatability scores on the hot meat were determined subjectively by the judges by use of a grading chart. The chart is a modification of that proposed by the Committee on Preparation Factors of the National Coöperative Investigation Board and described in *Meat and Meat Cookery* (1942). The factors considered were: intensity and desirability of odor and flavor; amount of juice; and tenderness. The amount of fat was noted in each case but, since both the venison and antelope fats were considered inedible by most of the

GRADING CHART FOR COOKED MEAT

Factors		5	4	3	2	1
Odor	Intensity	Pronounced	Moderately pronounced	Slightly pronounced	Noticeable	Faint
	Desirability	Desirable	Moderately desirable	Slightly desirable	Slightly undesirable	Undesirable
Flavor of lean	Intensity	Pronounced	Moderately pronounced	Slightly pronounced	Slightly noticeable	Faint
	Desirability	Desirable	Moderately desirable	Slightly desirable	Slightly undesirable	Undesirable
Tenderness	Intensity	Tender	Moderately tender	Slightly tender	Slightly tough	Tough
Amount of juice	Intensity	Juicy	Moderately juicy	Slightly juicy	Slightly dry	Dry

judges, and in certain seasons of the year there was no fat on the meat to be judged, it was not considered in the total scoring for palatability. The juice was judged by quantity rather than quality since it was frequently impossible to obtain enough for a qualitative analysis. Adjectives describing each degree of the qualities scored were weighted from 1 to 5. The higher numbers represent the adjectives describing the most intense or the most desirable state of the factor under consideration. The values reported for all factors are the opinions of four or five judges expressed numerically.

The total score, the highest possible being 20, includes only four factors: desirability of aroma; desirability of flavor; tenderness (by judges' score); and the amount of juice. It is customary to include both the intensity and desirability of flavor and of aroma in the total score. However, only the desirability of each factor was counted because it soon became evident that most of the judges disliked the strong, gamey, wild flavor and odor which they recorded as "pronounced," with a score of 5, and which would imply greater instead of less palatability. Figure 4, page 273, illustrates this tendency.

Methods for Vitamin, Fat (ether extract), Moisture, and Protein Analyses.

The vitamin, fat, moisture, and protein analyses were determined on composite samples of each cut of meat (ham, loin, or shoulder) made up in equal portions from each of the five deer in a group. Since Brady, Peterson, and Shaw (1944) found significant differences in the amount of thiamine and riboflavin in the different muscles of pork loin and also in riboflavin in beef (1944a), an effort was made to include equal amounts of each of the muscles in the cut of meat being analyzed. All of the meat in these samples was freed of visible fat and connective tissue, and ground and mixed five or six times in order to make a homogeneous sample.

The thiochrome method, as modified by Conner and Straub (1941), was used for the thiamine assays. Riboflavin determinations were made by the fluorometric method of Peterson, Brady, and Shaw (1943), and nicotinic acid was measured microbiologically by the method of Krehl, Strong, and Elvehjem (1943).

Moisture was determined by drying 5 or 6 gms of the ground meat, in a vacuum oven at 68° C, to constant weight. The ether extract was determined on the dried residue by continuous extraction for eight hours in a Soxhlet extractor.

Protein was determined as $N \times 6.25$, by macro-kjeldahl on the hams, loins, shoulders, and livers in only one group of deer and in none of the antelope.

RESULTS AND DISCUSSION

Generalizations as to the qualities of the meat on the basis of only five animals in a group of such varied general body condition and age, are not without danger of misinterpretation. However, since there was no way to determine age and general body condition in animals in the wild state until they were

killed, it was necessary to work with such groups. The variations were great in some cases, but certain general trends were evident.

DEER

Field Data. The average dressed weight, age, and general condition of the deer killed each month in Marin, Santa Barbara, and Ventura counties are shown graphically in figure 1.

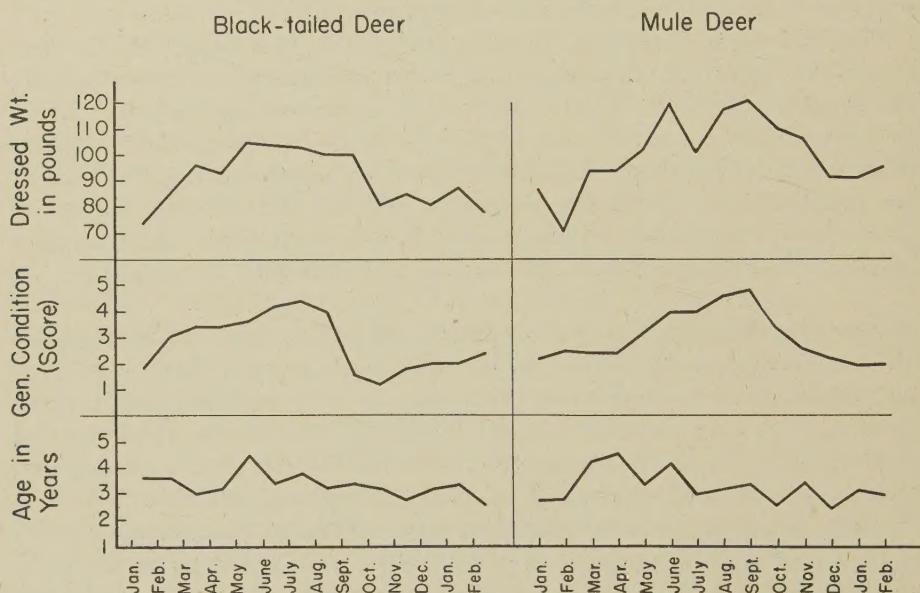


Fig. 1.—Average dressed weight, general condition, and estimated age of Columbian black-tailed and California mule deer.

Many of the irregularities shown in the weight curves of both groups of animals can be accounted for by the corresponding dips and rises in the estimated age curve. A definite seasonal trend was also seen. The weights of the Columbian black-tailed deer began to increase in the late winter and spring and reached a peak in May. They remained at approximately 100 pounds until the first of October and then dropped sharply to around 80 pounds where they remained, with fluctuations, for the rest of the sampling period which ended in February. The weights of the California mule deer reached a peak in August and September and declined through October, November, and December. In both groups of animals, the curves showing general condition followed closely those for weight.

The condition of the antlers, testes, and neck, at the different seasons of the year, are shown for both kinds of deer in figure 2. In the black-tailed deer, the antlers started budding in late March and early April and reached full size by July; they were hard in all specimens by the first of August and remained hard through November. In December, shedding had started, and

by the first of February, only one buck still retained his antlers. The antlers of the mule deer from southern California were hard from August through December. Two "stags," or emasculated deer, were among those killed in January and February, 1945. They account for the two bucks having antlers in the velvet in these months.

Swollen or bloodshot testes and swollen necks were considered an indication that bucks were breeding. Some of the black-tailed bucks apparently were

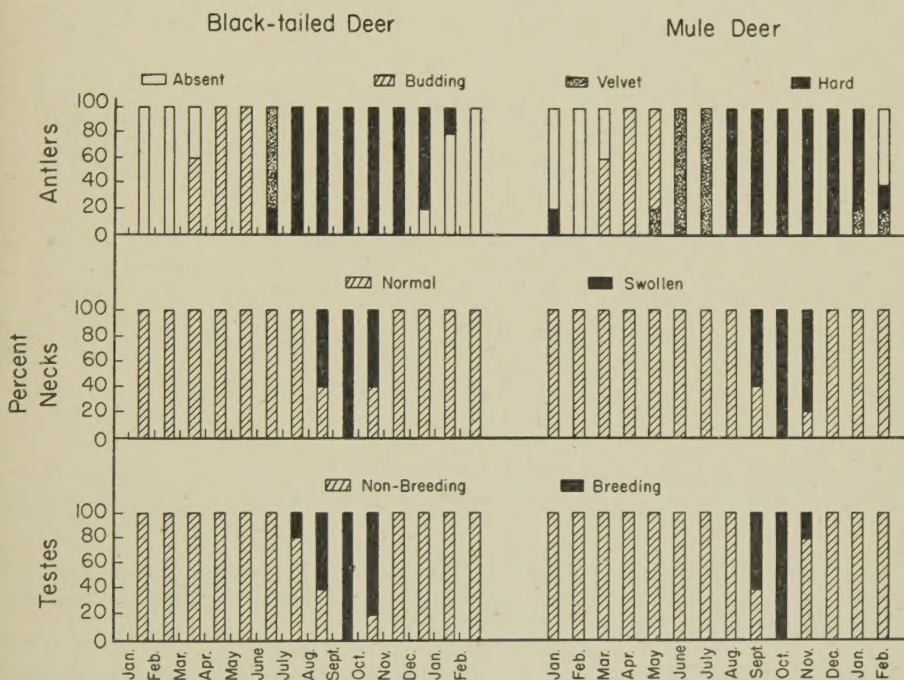


Fig. 2.—Condition of antlers, necks, and testes of Columbian black-tailed and California mule deer.

breeding in August; all were breeding in October. By the first of December, all activity was over. The height of the breeding activity in the mule deer, judged by the condition of the testes and necks, also occurred in October.

Palatability. In order to show the seasonal trends in the palatability factors graphically (figures 3 and 4), the scores for the hams and loins were averaged together. The livers seemed to show slightly different trends than did muscle meats and were, therefore, shown separately on the graphs. Because of the great variability in liver quality, the discussion of seasonal trends of the individual palatability factors and total score was based, except when otherwise stated, on the findings for the muscle cuts of meats.

It can be seen from figure 4 that there was close agreement between the judges' estimates of tenderness by score and that obtained by measuring the

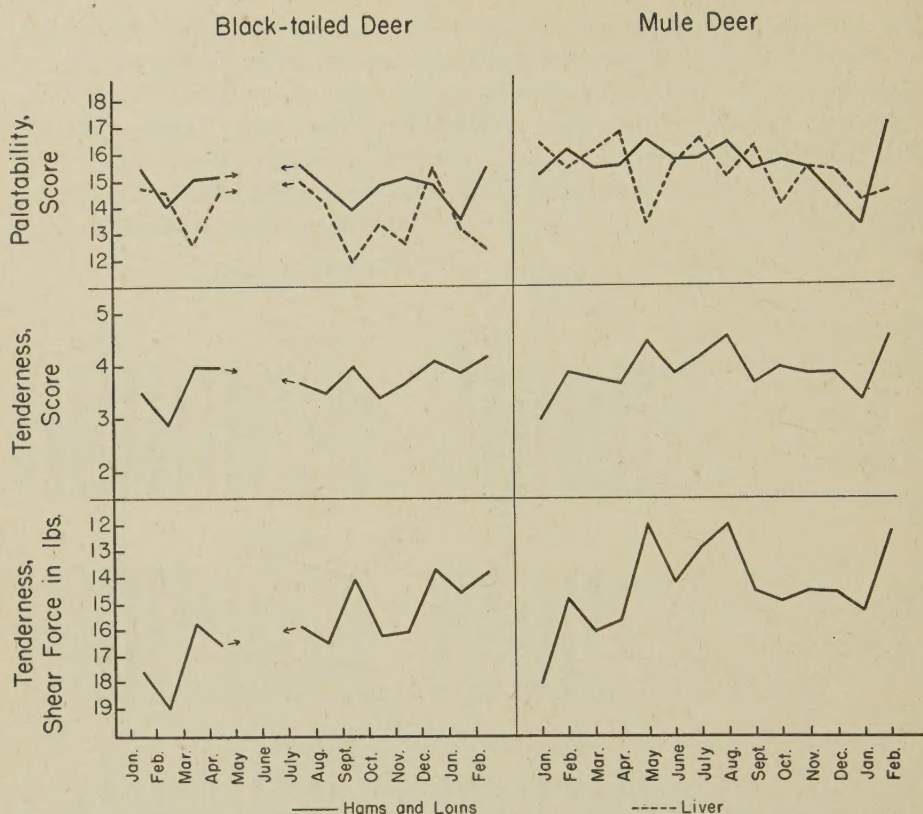


Fig. 3.—Average tenderness, measured by shearing force and by judges' score, and the total palatability score of the hams and loins (averaged together) and of the livers of Columbian black-tailed and California mule deer.

shearing force. The loins were more tender than the hams in both kinds of deer. The average (for 14 months) shearing force required for loins and hams of black-tailed deer was 14.7 ± 2.7 and 17.1 ± 3.1 pounds; for mule deer, 12.8 ± 2.8 and 15.9 ± 3.4 pounds. The mule deer meat was more tender than that of the black-tailed deer. The greatest tenderness occurred in the black-tailed deer meat in the middle of March, and in September and December of the first year, and in January and February at the beginning of the next year. Unfortunately, the May and June collections of the black-tailed deer disappeared from the freezing locker, and trends for these months can only be interpolated. It is quite likely that the meat was equally or even more tender in May and June, since the tenderness in both species at other times tended to parallel the general condition, which was excellent in those months. The toughest meat was found in February at the beginning of the experimental period; it was less tender in November and December than it had been earlier in the season. In the mule deer, greatest tenderness occurred from May through August the first year, and in February of the second year.

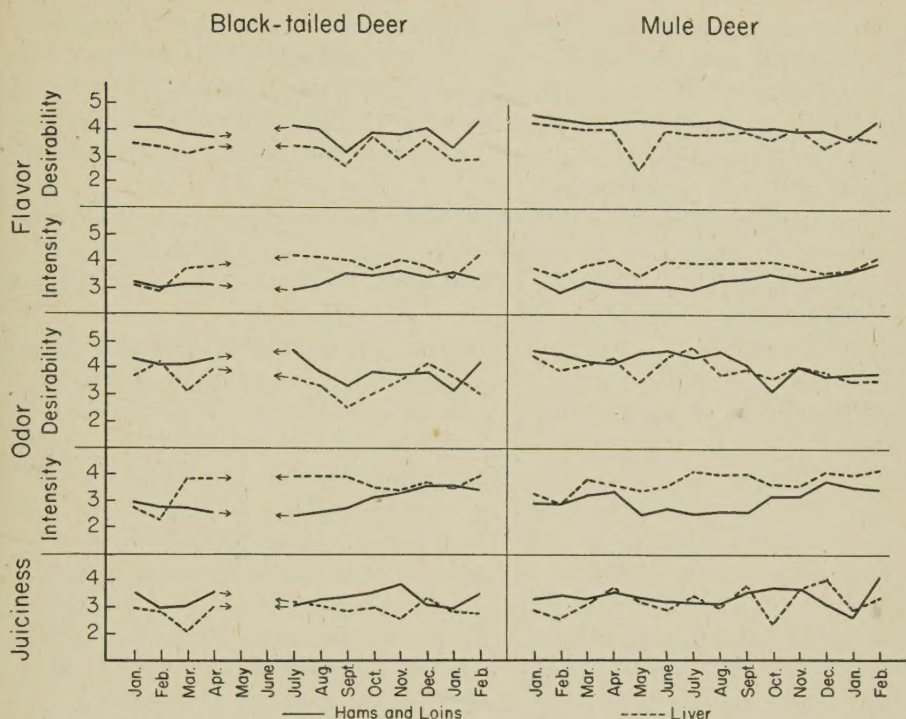


Fig. 4.—Average intensity and desirability of odor and flavor, and the juiciness of hams and loins (averaged together) and of the livers of Columbian black-tailed and California mule deer.

Though the peak of tenderness in the meat of both kinds of deer was found when the animals were reported to be in prime condition, the meat was also very tender in February at the end of the experimental period and when the general condition, though improved over that of November, was reported to be only fair. The tenderness found at the height of the breeding season was surprising; however, the general condition was declining rapidly at the time, and in November, after the breeding was over, the deer were all thin and the meat was generally tough. The toughness of muscle tissue may be accounted for as much by the increased exercise from running during breeding as by the loss of body fat.

Only slight monthly variation appeared in the desirability of flavor and odor in the muscle meats of the mule deer. The greatest variation was found in the livers which were reported to have a grassy, shrubby-like flavor in May and a musk-like flavor and odor in October. The same off-flavors and odors were reported in the livers and, to less extent, in the muscles of the black-tailed deer in April and October. The musk-like flavor observed in October in both groups of animals was obviously associated with breeding when glandular secretions are known to permeate the meat; the peculiar flavor which occurred in the spring was probably caused by a change in the kind

of forage. The flavor of the venison did not depend greatly on the degree of fatness in the animal. This is contrary to the findings of Satorius and Child (1938) who found a high degree of correlation between fatness and flavor in beef and pork. As stated before, venison fat was disliked by all of the judges; a few of them even objected to the meat of extremely fat animals, even though the fat itself was not consumed.

The total scores (figure 4) for palatability followed, with slight variations, somewhat the same general seasonal trend as the body condition except for the animals killed in the spring of 1945 when there was a rise in all factors of palatability. In the black-tailed deer, the highest scores occurred in the middle of January, in March and July, in October through December, and again the following February. The dips in the curve occurred in February and September of the first year and in January of the following season. In the mule deer, the meats were reported best in February, May, and August for the first year, and in February of the following year. The dips in the curve were slight, however, from February through August, and a steady decrease was noted after October or after the breeding season. Since both the mule and black-tailed deer killed in February of 1945 scored better in every way than animals killed the same month of the previous year, it was obvious that variability existed, not only at the different seasons of the year, but also from year to year. The latter variation probably arises from differences in range conditions resulting from climatic variations from season to season.

Vitamin Content. The averages of the thiamine, riboflavin, and nicotinic acid found in hams, loins, shoulders, and livers are summarized in table 1. The thiamine was determined in the hams and livers in all of the groups for the entire 14 months, and in the loins and shoulders for the last 8 months of the experiment. The riboflavin was measured in the hams, loins, and livers of the animals killed in the last 8 months, and the nicotinic acid only in the mule deer killed in January of 1945. Seasonal variations in thiamine and riboflavin for the period for which they were measured are shown in figure 5.

TABLE 1
AVERAGE THIAMINE AND RIBOFLAVIN CONTENT OF VENISON
IN MG PER 100 GMS OF FRESH WEIGHT
(All values are given with standard deviations.)

Cut of meat	Columbian black-tailed deer		California mule deer		
	Thiamine*	Riboflavin†	Thiamine*	Riboflavin†	Nicotinic acid‡
Ham.....*	0.21±0.04	0.41±0.08	0.23±0.04	0.50±0.08	5.9
Loin.....	0.23±0.04	0.47±0.04	0.27±0.05	0.55±0.06	8.0
Shoulder.....	0.20±0.03	.....	0.22±0.03	.....	5.0
Liver.....	0.57±0.04	5.06±0.46	0.60±0.18	5.26±0.71	12.0

* Average of hams and livers for 14 months and of loins and shoulders for the last eight months of the experiment.

† Average of all cuts for the last eight months.

‡ Values for only mule deer killed in January of 1945.

Though the cuts of meat were slightly higher in thiamine in the mule deer than in the black-tailed deer, the difference was not statistically significant, either on the wet or the dry basis. There was, however, a significantly greater amount of riboflavin in the tissues of the mule than in the black-tailed deer for the period in which the assays were made.

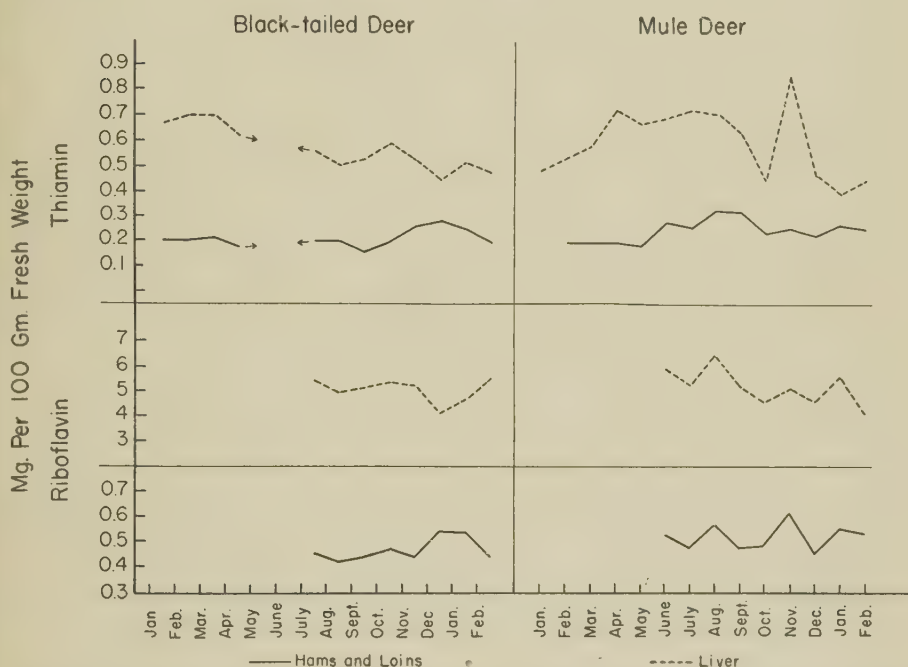


Fig. 5.—Average thiamine content each month for 14 months, and average riboflavin content for eight months, of hams and loins (averaged together) and of the livers of Columbian black-tailed and California mule deer.

The muscle cuts in the black-tailed deer were richest in thiamine in November, December, and January when the water content of the tissues was high and the general condition was reported to be poor. In the mule deer, the thiamine content of the muscles paralleled the body condition, increasing with an improved condition and decreasing as the condition became poor. The amount of thiamine in the livers of the black-tailed deer did not parallel that in the muscles as it did in the mule deer but tended to fluctuate in the opposite direction. It is difficult to say, with so few determinations, whether this difference is one of breed or of other factors unknown at this time. Pyke (1940), in a report on the thiamine content of pork muscle, gives values, for several breeds of swine, which vary widely and which suggest that breed as well as thiamine intake may explain somewhat the wide variations in the content of this vitamin. No data are given to show whether the thiamine content of pork livers paralleled that in the muscles or existed in inverse proportion to it.

The lowest thiamine values were found in both species of deer during the breeding season when there was much running and fighting. Since thiamine is concerned with the glycogen cycle, it seems logical to expect that because of the extra energy expenditure at this time, when greater amounts of glycogen are burned and more thiamine is required for its utilization, a decrease should occur in the amounts stored in the body tissues. Miller, *et al.* (1943) have reported increased muscle storage or accumulation of thiamine in pork as a result of feeding diets containing large amounts of the vitamin; the increase was greater in muscle than in liver. It is possible that in venison, also, the thiamine content varies with the intake of this vitamin in the food, and that forage may be richer in vitamin content at one season than in another. No attempt was made in this study to determine the intake of this vitamin.

The riboflavin in the muscles of the mule deer paralleled that in the liver; in the black-tailed deer, the opposite was true—as the amount increased in the muscle there was a corresponding decrease in that of the liver and vice versa. This suggests the possibility of a breed difference rather than a variation in storage of both riboflavin and thiamine.

Since the nicotinic acid content of the mule deer was determined only in the January sample at the end of the experimental period, no information as to seasonal changes was obtained.

Figure 6 shows the seasonal variations in the fat (ether extract) of the hams and loins together and of the livers. The ether extract, as was expected, followed the same trend as the general condition. The moisture content in both kinds of deer seemed to bear an inverse relationship to the amount of fat in the muscle tissues. For example, it was higher when the fat was lower and vice versa.

As stated earlier, the protein content of the different cuts of meat was determined on a composite sample of the five mule deer killed in January near the end of the experimental work. The values found were 21.09, 20.65, 21.69, and 21.17 per cent in ham, loin, shoulder, and liver, respectively. It is unlikely that there is a significant difference in the muscle tissues in the different cuts of meat since these differences come well within the expected accuracy of the method of determination.

ANTELOPE

Field data. The general body condition and dressed weight are shown graphically in figure 7, and the estimated age and condition of the necks and testes in figure 8, pages 278 and 279, respectively.

Using swollen necks and swollen and bloodshot testes as an indication of breeding, it would appear that all of the animals were breeding in September.

The ages of the animals in the groups studied each month varied greatly, especially in May and September when they ranged from 2 to 8 and 2½ to 8 years, respectively.

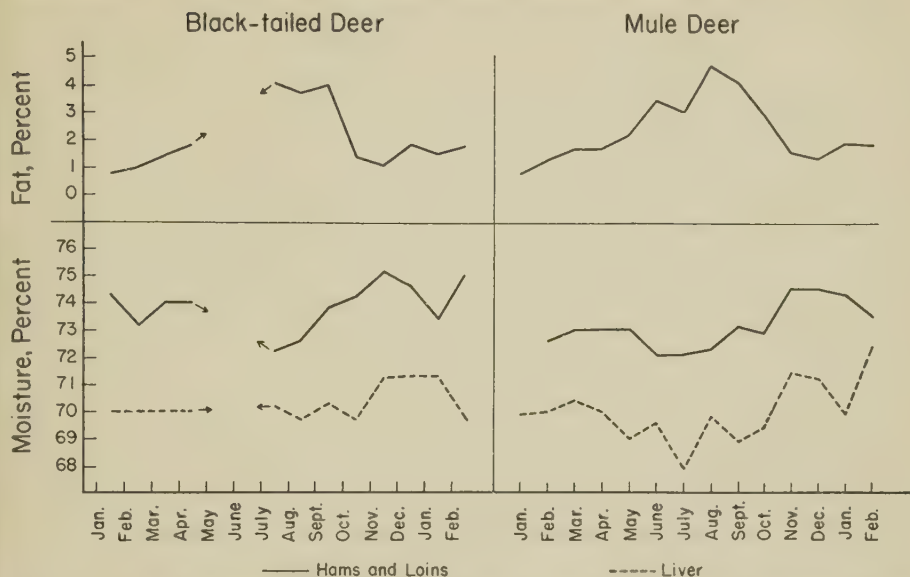


Fig. 6.—Average percentage of moisture and fat (ether extract) in the hams and loins (averaged together) and in the livers of Columbian black-tailed and California mule deer.

Palatability. A summary of the monthly averages of palatability factors and total scores is given in table 2, page 280. It can be seen that great variability existed in each of the groups studied and that in most cases the variation within the group was greater than that occurring from one month to the next.

On the average, the meat was very tender and, as in other animals, the loins were more tender than the hams. Antelope meat was more tender than venison, the average shearing force over the experimental period, for hams and loins, being 13.0 and 8.8 for antelope, and 17.1 and 14.7 for venison. The tenderness did not appear to be affected by the age of the animals. There were three in the September group ($2\frac{1}{2}$ to 8 years) for which the shearing force necessary to cut the loins was 9.5, 11.0, and 8.3. The greatest toughness was found in May and October when the age averaged 4 and $4\frac{1}{2}$ years, respectively. The general condition was reported to be poor in these months. In the fall, the toughness increased as it did in the deer, after and not during the rut.

The total scores were lowest in October after breeding was over. In addition to total scores, the judges were asked to rate the meat as poor, fair, medium, good, or excellent. These ratings and other comments by the judges are summarized in table 3, page 281.

Off-flavors were reported in certain animals in each group. All groups contained animals rated fair, medium, and good. The only antelope judged poor were killed in May and October; the others in these months were rated, except for one, fair to medium. Only one antelope was called excellent, and

Antelope

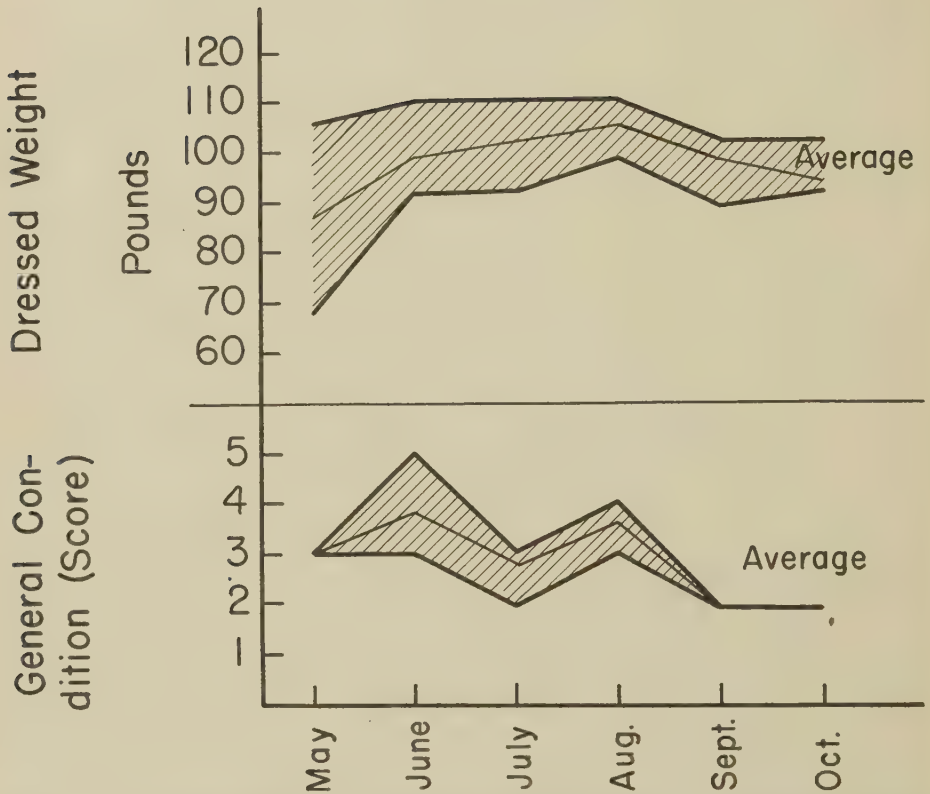


Fig. 7.—Average dressed weight and general condition of California prong-horned antelope.

it was killed in August. All but one of the September group were rated good. In spite of the great variation in individual specimens, it seemed that, on the whole, the quality was better in July, August, and September, the months when the animals were in prime condition.

It was difficult to find judges who were willing to taste the antelope meat, because it had a very gamey flavor and odor which probably explain the aversion to it. Those who consented to taste it liked it fairly well. Estimates based only on ratings by those who like a product might be open to question since such ratings would tend to be higher than those given by the average individual. However, it is possible to acquire tastes for unfamiliar foods, and this may be advantageous when there is a shortage of the more familiar ones. At such times, it may be desirable to substitute less familiar, but more plentiful, foods of equal or better nutritional value. Also, qualities appearing to one individual to be off-flavor or off-odor may be unnoticed by and even appeal to another.

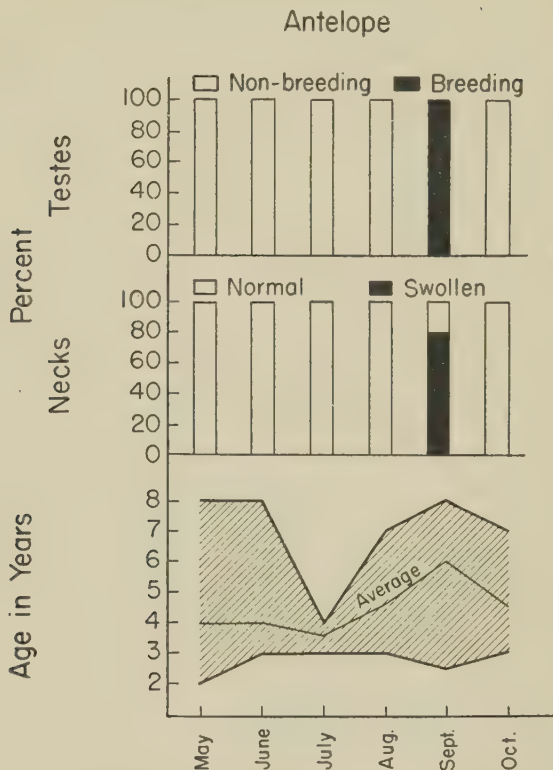


Fig. 8.—Condition of the necks and testes, and estimated age of California prong-horned antelope.

The Vitamin, Moisture, and Fat (ether extract) Content of Antelope Meat.

The values for moisture and fat, and for the thiamine and riboflavin content, for all cuts of meat, are given in tables 4 and 5, pages 281 and 282, respectively.

There was some difference in the moisture content of the tissues from month to month, with a tendency toward decrease in the muscles as the fat content increased.

In the muscle tissues, the amount of fat increased as the general condition improved, and decreased when the animals became poor. The ether extract in the liver varied in the opposite direction. This may mean that as the fat disappeared in the muscles, it was mobilized in the liver, or it may merely indicate the presence of other ether-soluble substances at this time.

The amount of thiamine was approximately the same, averaging over the six-month period, in mg per 100 gms of fresh tissue, 0.36 ± 0.03 (hams), 0.35 ± 0.02 (loins), and 0.35 ± 0.05 (livers). The shoulders contained considerably less— 0.27 ± 0.03 mg per 100 gms.

All cuts of antelope meat had a high thiamine content in May which decreased gradually to a low point in September, after which it increased. It is possible that there was increased thiamine intake in May when there was

TABLE 2
AVERAGES, WITH RANGES, OF PALATABILITY FACTORS AND THE TOTAL
SCORES FOR ANTELOPE HAM AND LOINS FOR SIX MONTHS

Month killed	Tenderness by:		Desirability of:		Amount of juice	Total score
	Shear force (lbs.)	Score	Odor	Flavor		
Hams						
May.....	16.0 (13.7-19.7)	3.4 (2.0-4.0)	3.6 (3.0-4.3)	3.2 (2.5-4.0)	3.2 (2.0-4.3)	12.8 (11.1-16.9)
June.....	8.7 (7.7-10.0)	4.1 (4.0-4.3)	3.8 (3.0-5.0)	3.5 (3.0-4.0)	4.1 (3.3-5.0)	15.3 (13.9-16.2)
July.....	13.2 (10.2-14.5)	4.0 (3.3-4.7)	4.0 (2.5-5.0)	3.6 (3.0-3.7)	4.0 (3.2-4.7)	15.6 (14.0-18.1)
August.....	14.4 (9.8-17.5)	3.3 (2.0-4.0)	3.7 (3.0-4.0)	3.7 (3.3-4.3)	3.6 (2.7-4.3)	14.3 (13.0-15.6)
September.....	9.7 (8.5-12.2)	4.6 (4.0-4.7)	3.6 (2.5-4.0)	4.0 (3.0-5.0)	4.1 (3.7-4.7)	16.3 (14.4-18.9)
October....	16.0 (11.7-20.0)	2.7 (2.0-3.0)	3.6 (2.5-4.5)	3.4 (2.3-5.0)	2.8 (2.0-3.7)	12.3 (10.6-14.7)
Average....	13.0	3.7	3.7	3.6	3.6	14.4
Loins						
May.....	9.9 (8.3-11.5)	4.2 (4.0-4.5)	4.2 (3.7-5.0)	3.6 (3.0-4.0)	3.0 (2.0-4.5)	15.1 (13.9-17.0)
June.....	8.0 (5.5-10.0)	4.0 (3.0-5.0)	4.6 (4.0-5.0)	3.6 (2.0-4.3)	3.1 (1.7-5.0)	14.9 (10.4-18.6)
July.....	6.8 (5.7-9.5)	4.3 (4.0-5.0)	3.6 (3.0-4.5)	3.8 (3.0-4.5)	3.5 (2.7-4.5)	15.1 (11.7-17.8)
August.....	7.7 (6.0-10.3)	4.5 (4.0-5.0)	4.0 (3.0-5.0)	3.4 (2.7-4.5)	3.4 (2.7-4.0)	15.1 (12.9-18.0)
September.....	9.2 (7.5-11.0)	4.3 (4.0-4.7)	3.9 (3.0-5.0)	4.1 (2.7-4.7)	4.0 (3.0-4.5)	16.3 (13.4-17.5)
October....	11.4 (8.0-17.2)	2.9 (1.3-4.2)	4.0 (3.0-5.0)	3.6 (2.7-4.7)	2.4 (2.2-2.7)	13.1 (10.9-15.6)
Average....	8.8	4.0	4.0	3.7	3.2	14.9

a new growth of forage. Miller, *et al.* (1943) found that as the amount of thiamine fed to hogs increased, the thiamine content of the meat increased. However, there is not sufficient evidence available to determine whether the antelope is like the bovine, which maintains its B-vitamin economy from the products of intestinal bacteria, or is partly or wholly dependent upon the vitamin content of the food eaten. The extremely low value in September, during breeding, compares with the decreased amount of the vitamin found in venison during the rut and it probably resulted, as explained before, from the increased activity of the animals at that time.

On the basis of mg per 100 gms of fresh weight, riboflavin averaged: 0.58 ± 0.05 (hams); 0.63 ± 0.04 (loins); 0.54 ± 0.04 (shoulders); and 5.1 ± 0.80 (livers). The amount of riboflavin in the liver was about eight times the amount found in the muscles, and it tended to increase or decrease along with the general condition. As in the mule deer, the amount of this vitamin in the liver and muscle tended to increase or decrease at the same time. In contrast with observations on thiamine, the lowest riboflavin values were found in October which was after, not during, the breeding period.

SUMMARY OF VENISON AND ANTELOPE STUDIES

According to the data obtained by the hunters, the bucks were in prime condition and the antlers were hard in August and early September, in both subspecies of coast deer.

On the basis of palatability and vitamin content, the meat of the California

TABLE 3
JUDGES' RATING OF ANTELOPE MEAT AND
COMMENTS ON EACH ANIMAL

Month killed	Animal number	Rating	Comment
May.....	21	Medium	
	22	Fair	Off-flavor
	23	Medium	Loin slightly dry
	24	Poor to fair	Off-flavor
	25	Medium	
June.....	16	Medium to good	
	17	Good	
	18	Fair to medium	Stringy
	19	Medium	Off-flavor
	20	Fair	Off-flavor
July.....	11	Medium to good	
	12	Medium to good	
	13	Good	
	14	Fair to medium	Off-flavor
	15	Fair to medium	
August.....	6	Fair	Off-flavor
	7	Medium	Off-flavor
	8	Excellent	
	9	Medium to good	
	10	Medium	
September.....	1	Good	
	2	Fair to medium	Slightly off-flavor
	3	Good	Off-odor
	4	Good	
	5	Good	
October.....	26	Fair to medium	Off-flavor
	27	Fair to medium	
	28	Medium to good	Off-flavor
	29	Fair	
	30	Poor to fair	Off-flavor

TABLE 4
AVERAGE MONTHLY PERCENTAGE OF MOISTURE AND FAT
(ETHER EXTRACT) IN SHOULDERS, LOINS, HAMS, AND
LIVERS OF FIVE ANTELOPE FOR SIX MONTHS

Month killed	Ham		Loin		Shoulder		Liver	
	Moisture	Fat	Moisture	Fat	Moisture	Fat	Moisture	Fat
May.....	73.8	2.0	72.8	2.6	74.8	2.9	70.1	6.6
June.....	73.1	3.6	72.0	5.0	74.5	4.0	71.8	6.3
July.....	74.0	4.4	71.9	5.5	74.8	3.7	69.7	6.0
August.....	72.5	4.5	71.2	6.0	74.4	4.3	70.7	6.4
September.....	73.0	2.3	72.5	4.2	75.5	2.7	71.8	6.6
October.....	74.3	1.2	73.0	1.1	75.5	0.9	71.3	8.2
Average.....	73.4	3.0	72.2	4.1	74.9	3.1	70.9	6.7

TABLE 5

THIAMINE AND RIBOFLAVIN CONTENT, IN MG PER 100 GMS OF
FRESH OR DRY, FAT-FREE TISSUES OF HAMS, LOINS,
SHOULDERS, AND LIVERS OF ANTELOPE

Month killed	Ham		Loin		Shoulder		Liver	
	Fresh weight	Dry fat-free	Fresh weight	Dry fat-free	Fresh weight	Dry fat-free	Fresh weight	Dry fat-free
Thiamine								
May.....	0.40	1.55	0.45	1.51	0.29	1.18	0.42	1.40
June.....	0.38	1.46	0.37	1.39	0.28	1.14	0.36	1.27
July.....	0.36	1.44	0.38	1.43	0.29	1.19	0.38	1.25
August.....	0.35	1.33	0.33	1.21	0.26	1.06	0.34	1.16
September.....	0.36	1.36	0.28	1.06	0.22	0.92	0.26	0.92
October.....	0.29	1.14	0.29	1.09	0.26	0.07	0.36	1.25
Average.....	0.36	1.38	0.35	1.28	0.27	1.09	0.35	1.21
Standard deviation.....	0.03	....	0.02	....	0.03	....	0.05	....
Riboflavin								
May.....	0.59	2.29	0.63	2.38	0.49	2.00	4.6	15.4
June.....	0.61	2.34	0.55	2.07	0.52	2.12	4.6	16.3
July.....	0.57	2.29	0.65	2.44	0.58	2.36	6.1	20.1
August.....	0.57	2.16	0.66	2.43	0.55	2.24	5.9	20.1
September.....	0.62	2.34	0.67	2.55	0.60	2.52	5.5	19.5
October.....	0.49	1.89	0.62	2.32	0.51	2.09	4.1	14.2
Average.....	0.58	2.22	0.63	2.36	0.54	2.22	5.1	17.6
Standard deviation.....	0.05	....	0.04	....	0.04	....	0.8	....

mule deer from Santa Barbara and Ventura counties was most desirable from June through August; that of the Columbian black-tailed deer from Marin County was most palatable from the middle of March through July. The vitamin content of the latter seemed to be highest in the winter months.

In tenderness and other palatability factors, the mule deer scored higher than the black-tailed deer; their tissues also contained a slightly higher percentage of the vitamins which were determined.

The thiamine and riboflavin content of the muscle meats paralleled that of the liver in the mule deer. In the black-tailed deer, as the vitamin content of the muscle increased, that of the liver decreased, and vice versa. This suggests the possibility of a breed difference in tissue storage of these vitamins.

Since both the mule and black-tailed deer killed in February of 1945 scored better in every way than those of the same species killed in February of the preceding year, it is obvious that variability exists, not only at different seasons in the year, but also from year to year. The yearly variation probably arises from climatic variations which result in differences in the amount of available forage.

TABLE 6

THIAMINE AND RIBOFLAVIN CONTENT, IN MG PER 100 GMS OF FRESH MEAT, OF CALIFORNIA MULE DEER, COLUMBIAN BLACK-TAILED DEER, CALIFORNIA PRONG-HORNED ANTELOPE, AND FOUR COMMERCIAL MEATS*

Animal	Thiamine				Riboflavin			
	Loin or rib	Ham, leg, or round	Shoulder	Liver	Loin or rib	Ham, leg, or round	Shoulder	Liver
Deer								
Black-tailed.....	0.23	0.21	0.20	0.57	0.47	0.41	....	5.06
Mule.....	0.27	0.23	0.22	0.60	0.55	0.50	....	5.26
Antelope.....	0.35	0.36	0.27	0.35	0.63	0.58	0.54	5.10
Beef.....	0.13	0.13	0.15	0.23	0.18	0.16	....	3.32
Veal.....	0.19†	0.18	0.17	0.19‡	0.31	0.31	0.32	2.43‡
Lamb.....	0.17	0.20	....	0.41	0.28	0.30	....	2.66
Pork.....	0.77-1.48	0.74-1.52	....	0.52	0.16-0.3	....	....	2.70

* The figures for beef, veal, lamb, and pork were taken from articles published by the following: Brady, *et al.*, 1944; Cover, *et al.*, 1944; Cover and Dilsaver, 1947; Waisman and Elvehjem, 1941; Hinman, *et al.*, 1944; McIntire *et al.*, 1943 and 1944.

† Sirloin.

‡ Baby beef.

Antelope meat in the months of May, June, July, September, and October was found to vary in palatability, not only from month to month, but also within the groups of animals killed each month.

The meat of only one animal was reported by the judges to be excellent, that of several was rated good, and of most, as medium in quality. The lowest ratings were given in May and September, the months when the animals were reported to be in poor condition. Off-flavors and odors were reported in all groups of animals. Some of these impressions were undoubtedly due to the fact that the flavor of antelope is entirely different from that of other meats and was reported in this way because of its unfamiliarity.

In most of the animals the meat was very tender. Over the period studied, it was found to be more tender than venison.

The thiamine content of the muscle meats equaled that of the livers. It was highest in May and lowest during the rut.

The riboflavin content of all antelope tissues studied was found to vary with the general condition of the animals and, as in the California mule deer, that in the muscles tended to parallel that found in the livers.

COMPARISON OF THE THIAMINE AND RIBOFLAVIN CONTENT OF VENISON AND ANTELOPE WITH SIMILAR CUTS OF COMMERCIAL MEATS

Table 6 shows the thiamine and riboflavin content of standard cuts of venison, antelope, beef, veal, lamb, and pork. Most of the values quoted from other reports are those determined by recently developed methods, chemical and microbiological. These methods tend to give lower values than do the rat assays which were formerly used and are, therefore, more comparable with those obtained by the similar methods used in this study.

The antelope hams and loins had more thiamine than the same cuts of either species of deer, and deer in turn had slightly more than beef, veal, or lamb. Pork hams and loins had about twice as much thiamine as the same cuts of antelope. Pork liver ranks with venison liver in thiamine; lamb and antelope come next; and beef and veal livers have the least of this vitamin.

Antelope hams and loins are the highest of all these meats in riboflavin; veal, pork, and lamb come next, and beef has the least. Antelope and venison livers excel in this vitamin, having approximately one and one-half times as much as the livers of any of the other animals. The muscular activity of the deer and antelope may be accepted as greatly in excess of that of domestic meat animals. This may account for the higher concentration of riboflavin found in the tissues of the former species.

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